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TECHNICAL REPORT
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# DEVELOPMENT OF REVERSIBLY COMPRESSED FREEZE-DRIED FOODS FOR USE IN INDIVIDUAL RATION PACKETS

by

J. M. Tuomy

June 1971

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760


Food Laboratory
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# DEVELOPMENT OF REVERSIBLY COMPRESSED FREEZE-DRIED FOODS FOR USE IN INDIVIDUAL RATION PACKETS

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## FOREWORD

Weight and bulk are two very important factors to be considered in the design of food packets to be carried by the combat soldier during periods when he cannot be resupplied. Freeze-drying results in highly acceptable foods which are light in weight. However, freeze-drying causes very little change in volume so that the products have a very low-bulk density. Previous work has shown that it is possible, with the use of suitable plasticizing agents, to compress such products as freeze-dried peas, cherries, diced meat, meat balls, etc., so as to achieve bulk savings equivalent to the weight savings. These products will assume their normal appearance upon rehydration. However, these particular products were not developed for individual ration use but are intended instead for kitchen preparation where hot water may be used for rehydration and time is not as important.

Foods appropriate for individual rations must be suitable for eating dry or for rehydrating in either hot or cold water in a short time. Since the products are usually combinations of many rather diverse ingredients and since the requirements for use are considerably more stringent, the compression of freeze-dried products for individual rations is more difficult to accomplish and has lagged behind the development of compressed products for kitchen use.

This investigation attempts through exploratory development to advance the art of compressing freeze-dried foods for individual rations. This report is concerned with Phase I of the effort in which prototype bars were to be developed. In Phase II, the developed bars will be evaluated in the field and further laboratory work will be continued to further elucidate quality parameters.

Funds for the work were furnished by the U. S. Army Land Warfare Laboratory under Project Number 71-09 dated 29 September 1970. Work has been accomplished primarily in the Animal Products and the Plant Products Divisions of the Food Laboratory. Necessary packaging was designed and supplied by the General Equipment and Packaging Laboratory.

Principal investigators in the Animal Products Division were 1st Lt Richard O. Shuler, Mr. Richard Helmer and SP4 Charles Brown. Principal investigators in the Plant Products Division were Dr. Abdul Rahman, Mr. Glenn R. Schafer, Mr. Harold Gorfien and SP5 David Dubose. Principal investigator in the General Equipment and Packaging Laboratory was Mr. Daniel J. Palese. Food Laboratory Project Officer was Mr. Justin M. Tuomy.

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ABSTRACT

Six combination meat prototype reversibly compressed bars were developed which are considered candidates for use in individual ration packets. In addition, four bars were developed in the plant products area which represent the areas of soups, salads, fruits and breakfast foods.

## Introduction

The funds provided by Land Warfare Laboratory order 71-09 require expenditure of approximately 1 man-year on the exploratory development and production of prototype components for potential seven-day strategic operations patrol rations/packets. The work is divided into two phases. Phase I is an exploratory development program intended to produce approximately 8 laboratory prototype reversibly compressed food bars and three molded bars. Phase II includes a semi-commercial pilot run of an estimated three prototypes and furnishing an estimated 1000 samples of each for field testing. This report covers Phase I.

The order calls for the primary effort to be in the area of animal product combination foods such as beef stew, chili, etc., although other foods are expected to be investigated. The reversibly compressed components are to be eaten dry or rehydrated in either hot or cold water, requiring a maximum of 10 minutes to restore normal appearance and texture. No additives may be used which have not been approved by the Food and Drug Administration.

## Technical Background

Foods contain a large amount of water, ranging from approximately 60 percent in cooked meat to over 90 percent in some fruits and vegetables. This water can be removed by freeze-drying to yield a dry product which is shelf stable and which, on the addition of water, is restored to a quality very close to that of the original wet material. However, freeze-drying does not change the volume to any appreciable extent; thus the dry foods have a very low bulk density and an internal structure closely resembling that of a sponge. It is obvious that a decrease in volume comparable to the weight savings accomplished through freeze-drying could be obtained if the products could be compressed and yet still be rehydrated back to their original configurations and textures.

Freeze-dried foods have moisture contents below 2 percent. Therefore, they are very brittle and crush to a powder under pressure. However, in-house work at the U. S. Army Natick Laboratories (NLABS) as well as contract work performed for NLABS has shown that, with the addition of a plasticizer, the foods can be compressed yet will come back to their original shape and appearance. This technique has been advanced far enough with single component foods such as peas or cherries that procurement documents have been written and production tests conducted with the intent of introducing the products into the supply system.

Although several chemicals can be used as plasticizers, moisture in amounts somewhere around 10 percent of the product weight, depending upon the particular product involved, is the easiest to use and the most satisfying. In the case of certain high sugar products such as cherries, heat instead of water can be used to plasticize them.

Although considerable progress has been made on the compression of single component foods, compression of combination foods such as stews is much less advanced. For one thing, compressed single component items have been designed primarily for use when kitchen facilities are available. They are not intended for eating in the dry state; rehydration can be accomplished with water at the most favorable temperature (usually hot), and rehydration time is not vitally important. Thus, they are not generally suitable for individual patrol rations or packet. Products for the latter purpose ordinarily are combination items and have to be suitable for eating dry and for rehydration in either hot or cold water within a very few minutes. Furthermore, foods are biological materials with widely varying compositions. Compression parameters can vary widely for the individual components of combination foods. For example, gravies and sauces compress to cement-like blocks which are almost impossible to rehydrate. Fats and oils can be expressed so that they coat each particle and act as water repellants. At the present time there is very little commercial interest in food compression and

very little information available in the scientific literature. Therefore, work under this order has to be the Edisonian approach of trial and error with statistically designed experiments being used to define parameters after prototype products have been developed. It is expected that the work will not only result in prototype items, but will define areas where more basic research will be of value for future development work.

Work on Phase I of the referenced order has been accomplished primarily by the Animal Products and Plant Products Divisions of the Food Laboratory. Necessary packaging has been designed and supplied by the General Equipment and Packaging Laboratory.

Procedures

With some exceptions due to the type of products involved, the products for compression were formulated, freeze-dried, moistened for plasticizing, equilibrated to a uniform moisture, compressed, redried to less than 2 percent moisture, and packaged under vacuum. Freeze-drying was accomplished with radiant heat, 100-125°F platen temperature, and 100-400 microns pressure. Moisture after freeze-drying was less than 2 percent.

Plasticizing the products was done by spreading them in trays and spraying with the correct weight of water to result in the amount needed for compression. The product was stirred and turned over several times during the spraying to obtain as even a distribution as possible. Equilibration was obtained by holding the moistened meat combination products under 27 inches of vacuum for 72 hours.

Compression was done on Carver laboratory presses. The dies used were 1 x 3 inches with the height of the bar being determined by the product characteristics and weight of product compressed. In general, 30 grams of material was used for each bar since this weight resulted in bars of a size which can be eaten easily out of hand. The mechanical parameters in compression are pressure and dwell time. The third important parameter during compression is the percent water in the material.

The compressed bars were redryed to less than 2 percent moisture by hot air, vacuum, or freeze drying. With the meat combination bars, freeze-drying and vacuum drying seemed to be better than air drying. Vacuum drying was used in most instances. The redried bars were usually packaged in laminated flexible pouches under vacuum.

One of the problems when dealing with new and different products such as compressed bars is that no test methodology has been developed. Both what to test and how to test must be established. It has been assumed for Phase I development effort that the following properties are important.

Hardness of the bar (difficulty in eating)

Brittleness of the bar (breaks up in handling)

Storage stability

Organoleptic acceptance of dry bar

Rehydration rates (hot and cold)

Breaking up of food pieces due to compression

Organoleptic acceptance of rehydrated bar

Hardness and brittleness can be determined by sophisticated instruments with the results then related to food acceptance studies and rough handling tests. However, for Phase I purposes it was decided to use a simple drop test by which various bars could be compared. As used currently, a 5/8 inch diameter steel ball guided by 3/4 inch diameter glass tubing is dropped a distance of 26 inches on to the bar resting upon a flat surface. The number of drops necessary to cause a break and the type of break are used for the evaluation.

Storage stability is determined by actual storage with evaluations at various time periods. A quick test is accomplished by storing the product for 14 days at 125°F. Standard storage studies on ration items are normally conducted at 40°, 70° and 100°F for one year with evaluation at 0, 3, 6, 9 and 12 months. Due to the short time frame, products in Phase I were normally given the quick test. Success or failure of the

product in this test is not conclusive evidence that the product will pass the normal test but does give good indication of its suitability for operational use.

Organoleptic acceptance of the dry bar is difficult to measure because there is very little past history to go by. In Phase I, the products were rated by technological panels consisting of 10 members who were familiar with this type of product. The ratings are of little value at this stage as related to acceptance by troops in the field. Their biggest value comes in comparison between bars and determination of treatment effects such as storage time.

Rehydration rates can be determined by weighing the product before and after rehydration with several bars being rehydrated for different times. However, for Phase I a simple shed test was used in order to save time considering the large number of variables being considered. In this test the bar is placed in a glass beaker and covered with hot water. Time is measured to the point where the bar falls apart completely. This test is not a very good indicator of the actual rehydration of a packaged bar, but does give a good indication of the effects of various treatments.

It was found that the shed test did not give good results when cold water was used. Therefore, a new test was developed. In this test the product is rehydrated with the correct amount of cold water ($70^{\circ}F$) for 10 minutes and then evaluated by a panel of 6 experienced technologists. Rehydration score is based on a 9-point scale where 1 is practically no rehydration, 5 is perfect rehydration and 9 is severe over rehydration.

Breaking up of food particles by compression can be determined with fair accuracy by a screening technique. However, it was not felt necessary to use this test during development stages since the technologist can adequately evaluate this by observation during the shed test.

Organoleptic acceptance of rehydrated bars was accomplished by technological panel evaluation. There is sufficient history with rehydrated freeze-dried food particularly in the Food Packet, Long Range Patrol (LRP) that the panel ratings are quite accurate and can be related to troop acceptance. However, actual results of the technological taste panels should not be taken as the actual numerical results that will be obtained in a field study.

Results and Discussion

Due to the short time frame it has been impossible to study each product in the intimate detail that would be necessary to develop a complete data package to be used in regular procurement. Rather, the effort has been directed toward developing prototypes that can be field tested and enough information obtained so that limited quantities can be procured for the field tests. It is expected that additional technical data will be obtained through further laboratory work during Phase II, from procuring the prototypes, and from the field test itself.

Foods that were investigated can be divided into four general categories. These are combination animal products (Group I), fruits and vegetables primarily as salads (Group II), soups (Group III), and bakery and cereal products (Group IV). The combination animal items were investigated by the Animal Products Division while the others were studied by the Plant Products Division. Since the products are so different not only from group to group but also within groups and because the approach had to be Edisonian, the work of the technologists was deliberately not standardized. Standardized acceptance parameters and testing will be developed at a later date. However, some of the test results for the most promising bars are given in Table I.

As a starting point in Group I the eight main components of the Food Packet, Long Range Patrol (LRP) were selected for initial evaluation. None of these products could be used as is. Some required only minor changes in formula or processing

while others needed major changes before they could be successfully reversibly compressed. In addition to the LRP items, several new LRP type items were developed specifically for compression.

Chili con carne.

Preliminary studies using the standard LRP product indicated that this product could be used with almost no change. The formula finally used was identical with the LRP formula. However, the fat content of the meat was reduced from 18-23 percent to about 12 percent. In order to obtain better rehydration the skin of the beans was slit. This produces a better product, but further evaluation is necessary to determine if the extra processing steps are justified.

Beef Hash.

Preliminary studies using the standard LRP product indicated that this product could be used with almost no change. Formula finally used was identical with the LRP formula. However, the potatoes were cooked less and the fat content of the meat was reduced from 18-23 percent to about 12 percent. Further work will be necessary to determine the maximum amount of fat that can be used.

Beef and Vegetables.

Preliminary studies with the LRP Beef Stew were unsuccessful since the product would not rehydrate no matter what moisture contents and pressures were used. Breaking down the formula and trying various combinations showed that two factors were causing the problem - excess fat and the use of Beef Soup and Gravy Base. Reformulation gave a highly successful product. In addition, the way in which the vegetables were handled gave a better appearing bar in that the colors were bright.

Formula for this product is

| Component | Percent by weight |
|---|---|
| Beef, cooked, diced | 25.0 |
| Potatoes, raw, diced | 35.0 |
| Peas, raw, slit | 9.0 |
| Carrots, raw, diced | 10.0 |
| Water | 18.0 |
| Seasoning Mix | 3.0 |
| | 100.0 |

| Seasoning Mix | |
|---|---|
| Salt | 50.0 |
| Onion powder | 2.0 |
| Pepper, white | 1.0 |
| Onions, dehy, minced | 10.0 |
| Hydrolyzed Plant Protein | 10.0 |
| Monosodium Glutamate | 1.0 |
| Sugar | 11.0 |
| Celery salt | 10.0 |
| Caramel color | 5.0 |
| | 100.0 |

Several different methods were tried in combining and cooking the ingredients. Although several methods gave acceptable bars, the best procedure was found to be cooking the vegetables separately, heating water and seasonings together to 180°F, then combining all ingredients and heating to 180°F.

Chicken and Vegetables.

Preliminary studies with the LRP chicken stew were unsuccessful for the same reasons as the LRP Beef Stew. Reformulating the product resulted in a successful bar. Formula for the revised product is

| Component | Percent by weight |
|---|---|
| Chicken, cooked, dried | 20.0 |
| Potatoes, cooked, diced | 27.1 |
| Peas, cooked, slit | 9.0 |
| Carrots, cooked, diced | 9.0 |
| Water | 30.4 |
| Gravy Mix | 4.5 |
| | 100.0 |

Gravy Mix

| | |
|---|---|
| Poultry seasoning | 0.25 |
| Monosodium glutamate | 0.15 |
| Milk, dry, nonfat | 35.00 |
| Starch, instant | 15.00 |
| Pepper, white | 0.60 |
| Garlic powder | 0.09 |
| Onions, dehy | 5.00 |
| Salt | 19.41 |
| Onion powder | 1.50 |
| Hydrolyzed vegetable protein | 3.00 |
| Sugar | 15.00 |
| Celery salt | 5.00 |
| | 100.00 |

Beans and Frankfurters.

Past experience with cured meat products and particularly those containing emulsions such as frankfurters has shown that in general they are not suitable for freeze-dehydration. However, a product such as Beans and Frankfurters would fit in well with a family of reversibly compressed bars and several formulations

were tried. It was found that if the frankfurters were sliced thin and were of the all-beef type a suitable product could be made. The formula for this product is

| Component | Percent by weight |
|---|---|
| Frankfurters, all-beef, sliced $\frac{1}{4}$ inch | 19.1 |
| Beans, Navy, cooked, slit | 35.1 |
| Tomato puree | 13.6 |
| Dry mix | 2.0 |
| Water | 21.8 |
| Catsup | 7.6 |
| Vinegar | 0.8 |
| | 100.0 |
| **Dry Mix** | |
| Beef Soup and Gravy Base | 37.3 |
| Sugar | 24.3 |
| Garlic powder | 0.2 |
| Onions, dehy, minced | 14.9 |
| Pepper, black | 0.7 |
| Mustard, dry | 1.3 |
| Paprika | 1.9 |
| Worcestershire sauce | 18.7 |
| Pepper, red | 0.7 |
| | 100.0 |

Beef & Rice, Chicken and Rice, Spanish Rice.

None of the rice products in the LRP could be successfully reversibly compressed. Various types of rice and various formulations were tried with only limited success. However, there is some evidence that further work could result in satisfactory products, but the limited time frame did not permit going into the problem further.

Chicken and Brown Rice.

Since products containing polished rice were not successfully reversibly compressed, brown rice was tried with both chicken and beef. With beef, the first attempts were not too successful although there were indications that it might be possible to be successful with some formula changes. However, chicken with brown rice worked out very well. The formula used is as follows:

| Component | Percent by weight |
|---|---|
| Chicken, cooked, diced | 25.8 |
| Rice, brown, cooked | 28.6 |
| Water | 34.4 |
| Seasoning | 2.6 |
| Pimientos, diced | 8.6 |
| | 100.0 |

| Seasoning | |
|---|---|
| Salt | 39.5 |
| Pepper, white | 0.5 |
| Monosodium glutamate | 1.0 |
| Onion powder | 5.0 |
| Hydrolyzed vegetable protein | 2.0 |
| Sugar | 13.0 |
| Celery Salt | 10.0 |
| Onions, dehy, minced | 12.0 |
| Poultry seasoning | 2.0 |
| Starch, Instant | 15.0 |
| | 100.0 |

Spaghetti with meat sauce.

Preliminary studies with this product using the LRP formula indicated that the compressed bars would be very good. However, storage at 100°F for 1 month showed extreme hardening of the bars so that they became difficult to eat dry and rehydration was impaired. Because of this the bar is not being considered for further work at this time. Reasons for the hardening are not completely understood and will require further investigation.

Pork with potatoes.

Preliminary studies were not very encouraging with this bar primarily because of the fat content and the white sauce causing problems. However, it is felt that a pork bar of some kind could be developed, but it was not pursued due to the limited time frame.

In Group II, eleven different combinations of ingredients were compressed and evaluated. These included such products as cole slaw, combination vegetables, and apple-nut. Two products were found promising enough for further work. These were Kidney Bean Salad and Cherry. Formulas for these products are

Kidney Bean Salad

| Component | Percent by weight |
|---|---|
| Kidney beans, canned | 61.6 |
| Celery, chopped | 8.1 |
| Eggs, boiled, chopped | 7.3 |
| Vinegar | 7.1 |
| Relish | 5.5 |
| Salad Dressing (Miracle Whip) | 5.4 |
| Peppers, green, chopped | 2.7 |
| Onion, chopped | 2.0 |

Cherry

| Component | Percent by weight |
|---|---|
| Salt | 0.26 |
| Pepper, black | 0.04 |
| Cherry | |
| Applesauce, dry, non-caking | 25.8 |
| Sugar | 22.7 |
| Potatoes, lemon flavored, diced ($12\%H_2O$) | 15.6 |
| Texgram, sour cherry flavor | 15.1 |
| Almonds, slivered | 10.9 |
| Cherry powder, F.D. | 4.5 |
| Cherries, maraschino, dried | 3.9 |
| Syloid 244 | 1.5 |

It is necessary to break the cherry bar into 4 or 5 pieces in order to obtain good rehydration.

In Group III, 14 types of soup products were studied. These could be broken down into four categories: commercial simmer type dried soups, commercial instant dried soups, freeze dried soups, and formulated soups. Initial evaluations indicated that none of the commercial soups would be satisfactory because they were too highly salted or seasoned to be eaten dry and they were not rehydratable in cold water. Freeze-dried soups were eliminated for about the same reasons. Special formulated soups prepared by using a matrix to which the soup formulations are added and then compressed, were found to be rehydratable in both hot and cold water. Of the soups investigated Beef Noodle was chosen for further work.

The formula used for the Beef Noodle Soup bar is:

| Component | Percent by weight |
|---|---|
| Freeze-dried ground beef | 31.40 |
| Freeze-dried noodles | 9.10 |
| Freeze-dried mushrooms | 9.40 |
| Hydrolyzed vegetable protein | 4.74 |
| White pepper | 0.08 |
| Celery seed | 0.14 |
| Parsley flakes | 0.14 |
| Caramel color #800 | 0.31 |
| Ribotide | 0.15 |
| Monosodium glutamate | 0.61 |
| Maltrin-10 | 25.10 |
| Freeze-dried ground beef, powdered | 9.40 |
| Glycerin solution (5 parts water to 95 glycerine by volume) | 9.43 |
| | 100.00 |

The glycerine solution (54°-70°C) is sprayed on maltrin and powdered ground beef. The remaining ingredients are blended in. No additional water is used.

In Group IV products, a cornflake and an oatmeal bar were developed. The oatmeal bar was found to be unsatisfactory because of poor rehydration characteristics and poor acceptance. The cornflake bar appeared to have promise and further work developed a satisfactory bar.

Formulation for the cornflake bar is as follows:

| Component | Percent by weight |
|---|---|
| Cornflakes | 33.3 |
| Powdered Sugar | 25.0 |
| Maltrin | 8.3 |
| Powdered Milk | 33.4 |
| | 100.0 |

The most difficult problem in preparation of the cornflake bar was obtaining uniform distribution of the ingredients. Unequal distribution causes relaxation and crumbling. After spraying with water to plasticize the material, only 24 hours was needed for equilibration rather than the 72 hours required for combination meat items.

While prototype bars specified in the order have been developed and found to be of such quality as to warrant field study, much more information is needed. Formulations will have to be studied in detail so that the best bars for the intended purpose can be obtained. For example, fat is needed in most products to improve flavor, increase caloric content, and decrease the sensation of dryness when the bars are eaten as is. However, fat will act as a water repellant especially when it has been dislocated by compression and smears the individual particles in the bar. While compression parameters have been investigated to some extent, more detailed studies must be conducted particularly in statistically designed experiments which will elucidate interactions between all the variables including formulations. Storage stability is not expected to be a problem since a large body of knowledge is available in this area from previous work on freeze-dried products. However, actual studies will have to be conducted with each bar to determine both oxygen uptake parameters and organoleptic effects.

Obtaining the correct moisture content in the freeze-dried bars so that they are properly plasticized for compression has been and is a problem. The most satisfactory method with most bars, particularly the meat combinations to date has been to spray the product with the required weight of water and allowing it to equilibrate under vacuum for 3 days. This method is not as precise as desired and requires time that will cause some problems in production. It is expected that it will be used in Phase II. However, work is going on in the Pioneering Research Laboratory and in the Food Laboratory in support of the overall Food Laboratory program which should result in a process which will permit rapid, accurate equilibration to the correct moisture content.

An important area in which more work will have to be done is in developing tests for evaluating quality of the finished bar. These tests will be used both in development work and for eventual procurement. For development work the tests can be complicated and detailed if necessary. However, for procurement the tests must be kept fairly simple particularly in view of the contractor inspection program now in effect.

Compression ratios have not been determined accurately for the products since the ratios depend in great measure on processing and compression factors which have been completely evaluated. However, with the meat combination products, the ratio will be approximately 3.5-4.5 to 1.

Several attempts were made to develop molded type bars but the results were not encouraging. Rehydration was very slow in all cases and it was felt that concentrated effort on the compressed bars would be more fruitful.

Conclusions

Six meat prototype combination reversibly compressed bars were developed meeting the criteria of the Land Warfare Laboratory order and which are considered candidates

for Phase II of the order in which they will be subjected to field evaluation. These are:

Chili con carne

Beef and Vegetables

Chicken and Vegetables

Chicken and Brown Rice

Beef Hash

Beans and Frankfurters

In the plant products area four bars were developed representing four classes of food. These are:

Cornflake

Cherry

Beef and Noodle Soup

Kidney Bean Salad

The work to date indicates that reversible compression of combination foods is feasible.

TABLE 1. Test results for bars to be used in Phase II

| | Beef and Vegetable | Chili con Carne | Beef Hash | Chicken and Vegetable | Chicken and Brown Rice | Beans and Frankfurters | Beef Noodle Soup | Kidney Bean Salad | Cherry | Corn Flake |
|---|---|---|---|---|---|---|---|---|---|---|
| Shed Test (Min) | 1 | 0.5 | 2 | 3.5 | 1.75 | 2.5 | | 5 | 2 | |
| Drop Test (No.) | 3 | 1.5 | 4 | 3.5 | 3 | 4 | 7 | 1 | 3 | 2 |
| Break Score 1/ | 5 | 3 | 4 | 5 | 5 | 5 | 5 | 4 | 5 | 3 |
| Pressure (PSI) | 1,180 | 2,356 | 1,180 | 1,180 | 295 | 590 | 150 | 1200 | 950 | 175-250 |
| Moisture (%) | 12 | 12 | 12 | 12 | 8 | 10 | 3.3 | 3.1 | 2-4 | 12.5 |
| Cold Rehy Score 2/ | 4.8 | 4.9 | 3.8 | 3.0 | 4.5 | 2.8 | | | | |
| Panel Scores (Dry) 3/ | | | | | | | | | | |
| Color | 7.2 | 6.6 | 7.0 | 6.8 | 7.0 | 6.5 | 6.1 | 6.6 | 6.8 | 7.4 |
| Odor | 6.6 | 6.7 | 6.8 | 6.1 | 6.9 | 6.4 | 6.0 | 6.3 | 7.2 | 7.4 |
| Flavor | 6.2 | 6.4 | 6.6 | 5.8 | 6.6 | 5.6 | 5.6 | 6.1 | 6.7 | 6.9 |
| Texture | 6.0 | 5.9 | 6.3 | 5.4 | 6.4 | 5.7 | 5.7 | 5.8 | 6.2 | 5.7 |
| Panel Scores (Rehy) | | | | | | | | | | |
| Color | 7.4 | 6.6 | 6.8 | 6.8 | 6.9 | 7.0 | 5.7 | 6.2 | 6.1 | 6.8 |
| Odor | 6.9 | 6.6 | 6.6 | 6.5 | 6.9 | 6.3 | 5.9 | 6.4 | 6.4 | 7.4 |
| Flavor | 6.7 | 6.4 | 6.5 | 6.4 | 6.9 | 6.3 | 5.0 | 6.1 | 5.3 | 7.1 |
| Texture | 6.3 | 6.3 | 6.0 | 6.0 | 6.9 | 5.4 | 5.6 | 5.3 | 5.3 | 6.7 |

1/ Based in evaluation of break at end of drop test. 5-very clean break, 4-clean break, 3 - some shattering, 2 - very much shattering, 1 - disintegrates.

2/ Based in organoleptic evaluation by 6 experienced technologists after 10 minutes of cold water rehydration based on a 9-point scale with 5 (Median point ) optimum rehydration. Over 5 would represent over-rehydration and under 5 would represent under-rehydration.

3/ Technological panel, 10-members, 9-point scale. These values should not be taken as any indication of acceptance in the field, but rather only for comparative evaluations of the bars and an indication of their technical ratings considering present state of the art.

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13. ABSTRACT

Six combination meat prototype reversibly compressed bars were developed which are considered candidates for use in individual ration packets. In addition, four bars were developed in the Plant Products area which represent the areas of soups, salads, fruits and breakfast foods.

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| Compressing | 8 | | | | | |
| Food bars | 2, 9 | | | | | |
| Meat | 1 | | | | | |
| Soups | 1 | | | | | |
| Salads | 1 | | | | | |
| Fruits | 1 | | | | | |
| Breakfast foods | 1 | | | | | |
| Military rations | 4 | | | | | |